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was ordered by the recent legislature, and succeeds the boards of regents of the university, the normal schools, the deaf and dumb school, the blind school, the girls' industrial school, the university preparatory schools, the various charitable institutions, etc.; and also succeeds the former text book commission. Governor Cruce, in his address to the members of this board, said in part: "I regard this board as the most important public body which has ever been, or ever will be constituted in this state. This is a radical departure from established methods, and it is impossible for me to overstate the interest and anxiety I feel for the successful outcome of your labors. I want to say, with all the emphasis that I can command, that politics absolutely be eliminated from educational matters in Oklahoma—as thoroughly as church and state are now divorced. Members of this board may be removed for cause, and I should regard it as good and ample cause for removal if any member should permit political or personal motives to influence him in the employment or discharge of persons connected with the state schools, or in any other matters coming within the jurisdiction of this board."

At its recent session the legislature of Kansas appropriated approximately one million dollars for the State Agricultural College at Manhattan for the next biennium. The funds provide for one wing of an agricultural building, with a detached laboratory for the cutting and curing of meats. The first wing of the new building is to cost \$125,000. Two more wings are to be added as the money is appropriated, each complete in itself. The legislature also provided a special fund of \$22,000 to complete the armory and gymnasium, which included literary society halls, swimming pools, and complete equipment for the whole; money for experiments in the western part of the state in cooperation with the federal government; for soil surveys, also in cooperation with the United States government, \$5,000 a year; for experiments in producing improved wheat, corn and other crops, \$7,500 a year. The college has this year approximately 2,500 students, more, it is said,

than are enrolled in any similar institution in the world. The cost per student in this institution in 1910 was \$107. Kansas, with a population of less than 1½ millions, had, in 1910, more students in colleges than had Missouri, with more than 4 million population. Illinois, in its agricultural college and university combined, had 4,638 students in 1910. Kansas, with its agricultural college and university separate, had 4,608 students, thirty fewer than Illinois, which has 6 million population.

MR. ANDREW CARNEGIE has given \$25,000 to the faculty of medical sciences of London for the section of a building to be devoted to pharmacology.

As has been noted here M. Loutreuil bequeathed \$500,000 to the University of Paris. The bequest is on condition that the provincial universities also shall benefit by the revenue which is to be devoted to the encouragement of scientific studies, the equipment of laboratories, the formation of a library and the foundation of additional lectureships on scientific subjects.

DR. LAJOS SCHLESINGER, of the University of Budapest, has been called to the chair of mathematics in Giessen as successor of Dr. Moritz Pasch.

At Princeton University Dr. H. N. Russell has been promoted to be professor of astronomy.

DISCUSSION AND CORRESPONDENCE

THE MEANING OF VITALISM

PROFESSOR RITTER's interesting address as vice-president of Section F of the American Association¹ makes manifest once more a difficulty which confronts every one who would discuss the question of vitalism: namely, the lack of either clear or generally accepted definitions of the terms ("vitalism" and "mechanism") used to designate the opposing doctrines under discussion. Professor Ritter himself is so sensible of this difficulty that he frankly gives up attempting any complete conformity to "lexicographical authority and historical usage," and simply puts forward

¹ SCIENCE, Vol. XXXIII., No. 847, March 17, 1911, pp. 437-441.

special definitions *ad hoc*, of his own formulation, as an indication of the particular doctrines with which he is for the time being concerned. This, of course, is a perfectly legitimate procedure; but even this wise precaution can free the ensuing discussion from irrelevancy and terminological confusion only upon three conditions: first, that the definition itself be unequivocal; second, that the writer subsequently use the term only in the sense defined; and third, that the sense given to it by his definition correspond to doctrines actually held by contemporary writers worth considering, and to the fundamental principles of those doctrines rather than to their adventitious details. I am not quite sure that the first two conditions are wholly fulfilled in Professor Ritter's discussion; his definition of vitalism seems to me diffuse and of rather elusive meaning, and it does not seem altogether clear that the vitalism with which some of his remarks deal is the vitalism defined. These, however, are merely questions of verbal consistency upon which it would be unprofitable to dilate. Of more material consequence is the third requirement; for if it be not fulfilled, the discussion, however clear and unambiguous, is unlikely to be pertinent to the controversy over vitalism, as an important contemporary issue. Do, then, Professor Ritter's definitions really expose the nerve of that issue? I am not convinced that they do. In order, however, to avoid a merely *ad hominem* argument, I should like to suggest another way of approaching the matter which seems to me more likely to expedite an ending of the controversy between mechanism and vitalism. I shall do so by indicating in the order of their logical priority what appear to be the three essential questions involved in the controversy, and the nature of the opposing views which may be, and have been, taken upon each of these questions.

1. The first question concerns the logical relation of the "laws" or generalizations of biology to those of other sciences. The mechanistic doctrine, whatever more it may imply, at least asserts that the explanations of organic processes can eventually be found in

the laws of some more "fundamental" science whose generalizations are more comprehensive than those of biology, covering some (or all) inorganic phenomena, as well as organic. The full mechanistic program would be realized if biological laws could be shown to be special cases of chemical laws; these in turn of physical, and these finally of the laws of mechanics. Roux, for example, thus sets down the aspiration of the science of *Entwicklungsmechanik*: *Das organische Geschehen . . . auf anorganische Wirkungsweisen zurückzuführen, es in solche Wirkungsweisen zu zerlegen, zu analysieren*. The vitalist, on the other hand, however much more he may assert, maintains at least the impossibility of this reduction of organic processes to the laws of the sciences of the inorganic. The first article of the creed of the recent defenders of vitalism, and perhaps the one article on which they are all agreed, is the principle of *Lebensautonomie*, which is thus formulated by von Hartmann: *Aus anorganischer Materie kann das Organische von selbst, d. h. nach anorganischer Gesetzmäßigkeit allein, nicht entstehen*.

But what precisely is the matter at issue here, and by what test, if it were available, could the issue be decided? In what would a *Zurückführung* of biology to chemistry or physics consist? It would consist in showing that a given organic process A can be subsumed under and *deduced from* a given generalization, B, of the more "fundamental" science. The proof of the autonomy of biology, on the other hand, would consist in showing that there are modes of action characteristic of matter when organized into a living body which can never be deduced from any law that describes any modes of action of inorganic matter. But here an explanation about deducibility is needful, since the notion has been somewhat confused in some recent discussions. From *no* general law alone, even if it is known to be true, can *any* more special law, or individual phenomenon, be deduced; and this follows from the very notion of a scientific law. For such laws are generalized statements of certain constant correlations *between two or more variables*; and in order

that from the law anything more specific shall be predicted or deduced, it is necessary that there be given empirically certain information concerning at least one of the variables. Without some empirical knowledge concerning the motions or masses of some bodies, nothing could be inferred about bodies from the law of gravitation. For this additional empirical knowledge about the actual values of the variables the laws themselves, if properly formulated, expressly call. But the undeducibility of biological from other laws, which the vitalist asserts, is not simply the undeducibility due to a lack of the specific empirical information called for by those other laws. What the vitalist maintains is that, even given a complete knowledge *both* of all the laws of motion of inorganic particles and of the actual configuration of the particles composing a living body at a given cross-section of time, you could not from such knowledge deduce what the motion of the particles, and the consequent action of the living body, would be. What he asserts primarily, in short, is the doctrine of the logical discontinuity, at certain points, of scientific laws. This discontinuity does not necessarily imply any breach of the principle of causal uniformity. Whenever a number of particles acting in accordance with one set of laws (*e. g.*, of mechanics) are brought into a certain configuration, they may conceivably thereafter take to moving in ways not correctly described by the aforesaid laws; if so, the conditions under which the shift from one mode of action (*i. e.*, action of which a correct generalized description is given by the one set of laws) to the other mode takes place are uniform, and a new law may be formulated setting forth that very uniformity of discontinuity. Again, such a view would not, in itself, deny that the behavior of organisms is a function of the number and configuration of the material particles composing them.

Such a doctrine of the autonomy of a given science might conceivably be applied to other sciences besides biology. It might be held, for example, that chemistry is similarly autonomous with respect to physics, or psychol-

ogy with respect to biology. It might, again, be maintained that the real point of discontinuity comes, not where chemistry connects with biology, but rather where physics connects with chemistry—biological phenomena being in themselves theoretically inferrible from chemical laws, when chemical laws are more adequately known. I do not now inquire whether any such views are plausible or not; I merely point out that vitalism is first of all a special case of what might be called scientific autonomism, or logical pluralism. Mechanism, meanwhile, asserts the possibility of an eventual unification of scientific laws. Between the two is possible an agnostic position, based upon the observation that both sides agree that no such unification is yet achieved, and that both have some difficulty in proving either that it must be or that it can not be achieved in the future.

In so much of vitalism, however, there appears to be nothing that can properly be called “mystical” or “transcendental,” nor anything that can especially profitably be regarded as a survival of primitive animism.

2. There is, however, a doctrine which goes beyond this mere assertion of organic autonomy, and declares that (in part) the action of living bodies *is not strictly a function of the number and spatial configuration of the particles composing them at any given instant*. In other words, organisms not only have unique laws of their own, but these laws can not even be stated in terms of the number and arrangement of the organism's physical components. Not all who call themselves, or have been called, vitalists assert so much as this; but the neo-vitalism of Driesch maintains precisely this view, and endeavors to support it by definite empirical evidence. Driesch seeks in the phenomena of regulation, regeneration and conscious behavior, evidence for the assertion that the composition (physical and chemical) of an organism, on the one hand, and its morphogenesis and activity, on the other, are (to some extent) independent variables. With a radical variation in composition—*e. g.*, after the elimination of half the blastomeres at a certain stage of develop-

ment in certain embryos—you may, he contends, get an identical resultant form (except with respect to size). About the experimental facts there can be no question; though there appears to me to be a fairly evident flaw, of a purely logical sort, in the inference which Driesch draws from them. I do not, however, wish here to discuss the truth of vitalism, but merely to elucidate its import. But even for the latter purpose it is important to note that Driesch's vitalism by no means maintains that the specific properties or activities of organisms are not functions of *any* antecedent material or physico-chemical configuration. Whales do not develop from sea-urchin's eggs, nor does the unfertilized egg develop at all. Always you must first have given a definite mechanism, at the beginning of any morphogenetic or other vital process; and for different products you must have different original mechanisms. All that Driesch maintains is that such a process once started continues towards its normal consummation even if, after the start, some of the usual machinery instrumental to that consummation is lost and the rest has to redistribute and redifferentiate itself in order to keep things moving in the customary manner. In short, even the processes in which Driesch finds the independent variability of the physical mechanism of a living body and its physiological processes exemplified, still, even for him, have perfectly definite, perceptible and experimentally ascertainable constant antecedents, if you go back to an early enough stage in the given sequence of processes.

3. The fundamental questions concerning vitalism are the first two questions: Can some biological phenomena be shown to be, in the sense defined, autonomous? and can some of them even be shown not to be functions of any fixed configuration of material parts existing in the organism or cell at the moments at which the phenomena take place? Now, one might conceivably answer one or both of these questions in the affirmative, and stop there. Such would be the procedure of a convinced vitalist who had caught the spirit of scientific positivism. But most vitalists, undoubtedly,

are not of a positivistic temper, and they have accordingly often gone on to account for the asserted peculiarity or uniqueness of organic *processes* by hypostatizing special *forces* or agents as causes of these peculiar modes of action. Such hypostases have been made in three different fashions by three recent schools of biological philosophers, of which the first would apparently refuse to be called vitalistic. The qualitative *Energetiker* (e. g., Ostwald, Rignano) in so far as they set up as a real entity a specific vital or neural form of energy, having properties and modes of action not characteristic of energy in any other of its transformations, seem to imply both the autonomy of organic phenomena and the need of postulating a special dynamic background for these phenomena. The psycho-vitalists (who are indeed biological animists), such as Pauly, Francé, Strecker, find the cause of the unique modes of physical behavior distinctive of organisms in a *seelisches Innenleben*, a rudimentary form of consciousness and of purposive action, ascribed to even the simplest living things. And Driesch and Reinke and their followers, in order to explain how organisms can, as these biologists believe, pursue their typical ends even after a considerable modification or partial destruction of their usual machinery, postulate "entelechies" or "dominants" having the power, so to say, to take command even of a disabled organic ship and steer it (under certain conditions) to its destined port.

Now, it is doubtless in these vitalistic hypostases that Professor Ritter finds the trait which makes vitalism resemble savage animism. I wish, therefore, to insist upon two considerations in this connection. In the first place, as I have tried to show, the question whether it is worth while to set up such hypostases, not open to direct observation, is wholly subsidiary to questions 1 and 2, which have to do with potentially ascertainable facts concerning the *laws* of organic processes. If the verdict upon either of those questions goes in favor of the vitalist's contention, the main issue is settled. Whether, vitalism being assumed, it would be worth while to postulate

hypothetical and imperceptible forces or entities to account for the perceptible facts, is essentially a question of scientific convenience. The presumption, surely, is in favor of the positivistic method, which is content to correlate the observable data without going behind them. Yet it must be confessed that it is not by such avoidance of hypotheses concerning imperceptible causes or substances that physics and chemistry have achieved their best results. And the precedent of those sciences might be plausibly (though, I think, unwisely) made, by one convinced of the truth of the vitalistic answer to one or the other of the first two questions, an excuse for not taking his vitalism positivistically or pragmatically. In any case, these hypothetical "forces" or causes would constitute elaborations or embellishments of his doctrine; they would not constitute the basis or the irreducible minimum of it.

A word in conclusion about the position of Bergson, of which Professor Ritter speaks with cordial approval. Bergson holds the doctrine of organic autonomy in a special and a somewhat extreme form. Inorganic and organic processes manifest, in his opinion, radically dissimilar modes of causality. "The present state of an inanimate body depends exclusively upon what took place at the preceding instant. The position of the material points of a system is determined by the position of the same points at the immediately antecedent moment. In other words, the laws which control unorganized matter can be expressed in differential equations in which *time* (in the mathematician's sense) plays the part of an independent variable." This, Bergson insists, is not true of living bodies; their present state does *not* "find its complete explanation in the immediately anterior state." We must absolutely give up "the idea that the living body could be subjected by some superhuman calculator to the same mathematical treatment as that which is applied to our solar system." The "creative" efficacy of organic evolution is shown, for Bergson, precisely in the impossibility of deriving from even the most complete knowledge of the configuration

of the components of an organism at a given moment, and of all the "laws" which have been disclosed up to that moment, any absolutely complete and certain knowledge of the future condition and action of that organism. Bergson, moreover, does not stop with this anti-mechanistic view of the actual behavior of organisms; he suggests an explanation for what he conceives to be the facts. And his explanation, though rather elusive, approximates that given by the psycho-vitalists. The neo-Lamarckians, he declares, are right in referring organic evolution to "a cause of the psychological order," though they apprehend this too narrowly. The conception of "effort" should be taken in a sense more profound, a sense even more psychological, than any neo-Lamarckian has supposed." It is true that Bergson does not seem to call his doctrine vitalism, and that he speaks in criticism of the vitalism of certain other writers. But it seems to me that any dogmatic (*i. e.*, not merely provisional or agnostic) anti-mechanism in biology should be called vitalism. In other words, the doctrine which it appears to me to be linguistically most convenient to designate by that name is the doctrine of organic autonomy in its biological application, the assertion of an essential logical discontinuity between the "laws" or modes of action of matter dealt with by biology and the "laws" of all the sciences of the inorganic. And in this sense, of course, Bergson is an unmistakable and a radical vitalist. It would certainly be paradoxical to withhold the name from a writer who does not hesitate to say that the "parts of an organized machine do not correspond to parts of the work of organization, since the *materiality of this machine does not represent a sum of means employed, but a sum of obstacles avoided*" by the *élan vital* in its form-creating activity.

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PRODUCTIVITY OF SOILS

THE discussion of the "Secular Maintenance of Soils" by Professor Chamberlin